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(71) Applicant: **DEPARIA ENGINEERING S.R.L.**
23885 Calolziocorte (Lecco) (IT)

(72) Inventor: **Vergani, Cristiano Carlo**
23885 Calolziocorte (Lecco) (IT)

(74) Representative: **Cicogna, Franco**
Ufficio Internazionale Brevetti
Dott.Prof. Franco Cicogna
Via Visconti di Modrone, 14/A
20122 Milano (IT)

(54) Air cleaner including a cold-plasma electrostatic catalytic device

(57) An air cleaner is herein disclosed, said air cleaner being characterized in that it comprises a cold-plasma electrostatic catalytic device, comprising a supporting framework (6) and a sandwich construction, including a metal net (5) coupled to a high voltage generator (7), a perforated layer of polyester fibers (2), loaded by activated carbons, a polyester fiber layer (3) coated by a thin film of titanium dioxide (TiO_2), a polyester fiber layer (4) coated by activated carbon, and a metal net (8) coupled to the ground of said high voltage generator (7).

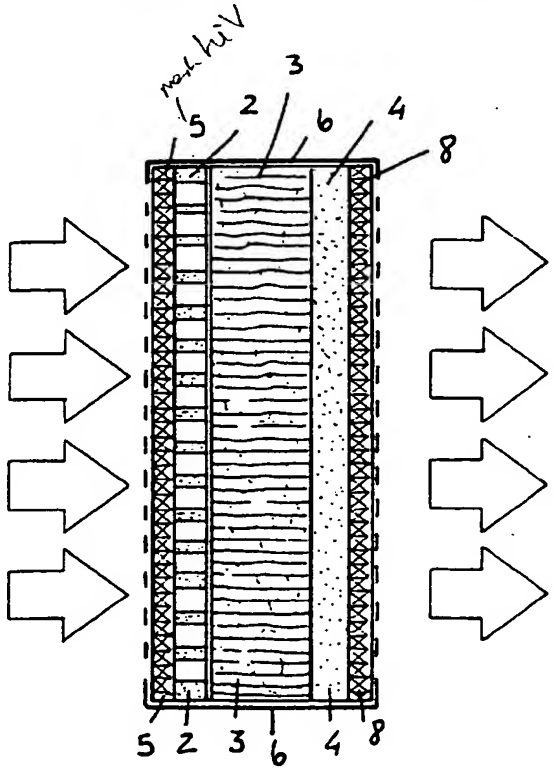

FIG. 2

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tions and further polluting fractions of different natures.

[0024] Yet another object of invention is to provide such an electrostatic filter operating with a comparatively low power consume, and which can be assembled and serviced in a comparatively short time and which, moreover, is very reliable and safe in operation.

[0025] According to one aspect of the present invention, the above mentioned aim and objects, as well as yet other objects, which will become more apparent hereinafter, are achieved by an air cleaner which comprises an electrostatic catalytic device, operating based on the cold plasma properties.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Further characteristics and advantages of the present invention will become more apparent hereinafter from the following detailed disclosure of the preferred, though not exclusive, embodiment of an air cleaner including a cold-plasma electrostatic catalytic device, and which is illustrated, by way of an indicative, but not limitative, example in the figures of the accompanying drawings, where:

Figure 1 is a perspective view of an air cleaner according to the present invention;

Figure 2 is a cross-sectioned side view of the air cleaner according to the invention;

Figure 3 illustrates the operating principle of the electrostatic air cleaner according to the invention;

Figure 4 is a 3-D exploded view illustrating a modified embodiment of the air cleaner according to the present invention, including an interexchangeable cartridge.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0027] With reference to the number references of the above mentioned figures, the air cleaner according to the present invention, which has been generally indicated by the reference number 1, comprises a supporting framework, generally indicated by the reference number 6, including, through the overall depth thereof, a sandwich construction, comprising a metal net 5, coupled to a high voltage generator 7, with a polyester fiber perforated layer 2 loaded with active carbons, a polyester fiber layer 3, covered by a thin film of titanium dioxide (TiO_2), a polyester fiber layer 4, coated by an activated carbon coating, a metal net 8 coupled to the ground of said high voltage generator 7.

[0028] The elements 5 and 2 form an electrode of a device for generating a strong flow of free electrons, unstable ions and molecules, of a strongly reactive type.

[0029] The above mentioned flow is called "cold plasma" or non-thermal plasma, for distinguishing it from a thermal status plasma in which the molecular ionization is induced by the thermal energy produced by a temperature increase.

[0030] The non thermal or cold plasma, on the contrary, is generated by an electromagnetic energy, i.e. by applying a high pulsed potential difference with respect to a reference electrode comprising the stages 4 and 8 and being electrically coupled to the ground.

[0031] Said potential difference will provide, by induction, an electric field having a corresponding amplitude or strength and an opposite orientation, which operates to perform an ionizing process.

[0032] The mentioned layer 3 is traversed by the above disclosed flow, and, being arranged between the two mentioned electrodes, it will have a double function of collector or manifold and of catalytic reactor.

[0033] The polluting particle fraction, being suspended in air, as it is subjected to said cold plasma, will assume an electrostatic charge allowing it to be attracted by the polyester fibers of the layer 3, having an opposite-sign electrostatic charge.

[0034] Depending on the acquired charge amount, which, in turn, depends on the physical-geometrical and chemical characteristics of the individual particles, the latter will be attracted by the fibers of the layer 3 or the fibers of the following layer 4.

[0035] Then, in their trajectory path, corresponding to the layer 3, the volatile organic substances are subjected to an oxidation process.

[0036] In fact, the cold plasma is characterized by the presence of greatly accelerated and energetic electrons, which, by impacting against the environment-temperature air molecules, will form oxidating radicals OH^- and O^-, which can directly react with the polluting substances to form other oxidating substances such as O_3, OOH, O_{2-}.

[0037] Moreover, a great photon amounts having a wave length in the UV spectrum range from 160 to 220 nm, and providing two important effects, are generated.

[0038] The first of said effect is the actuating of the photocatalytic properties of said titanium dioxide, due to the passage of the electrons from the valence band to the conductive band, for which it is sufficient the energy of a photon of 3.2 eV, that is at a wave length less than 387 nm.

[0039] In particular, the photons generated inside the plasma are suitable to activate or energize said titanium dioxide, thereby forming, after a series of reactions involving charge transfers, further free oxidating radicals.

[0040] A direct consequence of this is that the polluting molecules, which are passing through an environment saturated by strongly oxidating chemical species, are quickly decomposed.

[0041] The second effect is that of a strong biocide action, due to the UV radiation (160-220 nm), to which the most part of pathogen microorganisms are greatly sensible, owing to the irreversible and noxious alterations produced by the UV radiation in the intracellular structure; for example, a formation of free radical in cytoplasm.

said box element can be removed and replaced by a new one, thereby recovering the full operating capabilities of the air cleaning device.

[0064] Said metal framework is characterized by a shape, a size and an electric contact arrangement suitable to allow to easily replace the commercially available electrostatic filters in finished apparatus, without requiring any modifications of the supporting structures.

[0065] Moreover, it is provided to deposit, on the air exposed gaseous substance structures, a titanium dioxide (TiO_2) film of an Anatase or Rutile type, or in a mixture according to any desired mixing ratio, with an optional addition of substances suitable to extend the wave length range of the electromagnetic radiation necessary to activate said TiO_2, such as Ru and the like compounds, according to the following method:

a) preparing of a 15% solution of polyvinyl alcohol in water; immersing the particle material to be coated into this solution and then drying to room temperature;
b) providing a 15% suspension of TiO_2 in water;
c) immersing the particle material to be coated into said suspension and percolating the excess material;
d) quickly drying the particle material through the exposition to a RF field having a frequency from 2 to 4 GHz for few seconds.

[0066] The above method allows to make a firm coating, of a highly reactive nature, since it does not include polluting substances, and this without damaging the supporting material even if the latter comprises a material having a poor resistance against high temperature and organic solvents, such as polyester fibers.

[0067] From the above disclosure it should be apparent that the invention fully achieves the intended aim and objects.

[0068] In particular, the fact is to be pointed out that an electrostatic air cleaner has been provided, characterized by the use of a cold plasma barrier, i.e. at room temperature, specifically designed for providing an optimum broad spectrum filtering of the polluting substances.

[0069] This air cleaner has a very high filtering efficiency, very low making and servicing costs, and a very small power drain.

[0070] The invention, as disclosed, is susceptible to several modifications and variations, all of which will come within the scope of the invention.

[0071] Moreover, all of the constructional details can be replaced by other technically equivalent elements.

[0072] In practicing the invention, the used materials, as well as the contingent size and shapes, can be any, depending on requirements.

Claims

1. An air cleaner, **characterized in that** said air cleaner comprises a cold-plasma electrostatic catalytic device.

2. An air cleaner, according to Claim 1, **characterized in that** said air cleaner comprises a supporting framework (6) and a sandwich construction, including a metal net (5) coupled to a high voltage generator (7), a perforated layer of polyester fibers (2), loaded by activated carbons, a polyester fiber layer (3) coated by a thin film of titanium dioxide (TiO_2), a polyester fiber layer (4) coated by activated carbon, and a metal net (8) coupled to the ground of said gigh voltage generator (7).

3. An air cleaner, according to one or more of the preceding claims, **characterized in that** said metal net (5) and polyester fiber layer (2) provide an electrode of a device for generating a strong free electron flow, ions and strongly reactive unstable molecules, the so-called cold plasma.

4. An air cleaner, according to one or more of the preceding claims, **characterized in that** said cold plasma, i.e. a non thermal plasma, is generated by an electromagnetic energy induced by a high pulsed potential difference, provided by said high voltage generator (7) and directed toward a reference electrode including said polyester fiber layer (4) and said metal net (8) and electrically coupled to said ground or earth of said high voltage generator (7).

5. An air cleaner, according to one or more of the preceding claims, **characterized in that** said layer (3) is traversed by a free electron, ion, ionized molecule flow, of a unstable and great reactive nature, and being intertwined between two electrodes, the first of which includes said metal net (5) and layer (2) and the second of which includes said layers (4) and (8).

6. An air cleaner, according to one or more of the preceding claims, **characterized in that** the polluting particle fraction suspended in the gaseous or air substance and affected by said cold plasma, assumes an electrostatic charge allowing it to be picked up by the polyester fibers of said layer (3) having an opposite-sign electrostatic charge.

7. An air cleaner, according to one or more of the preceding claims, **characterized in that** the single particles of said polluting fraction suspended in said gas or air substance, depending on the acquired charge amount, which in turn depends on physical-geometrical parameters, are attracted by said fibers of said layer (3) and of said following layer (4).

said gaseous or air substance directed to following constructions; said windings being coupled to a suitable RF generator, to provide said plasma in said gaseous or air substance.

19. An air cleaning device, according to one or more of the preceding claims, **characterized in that** the construction disclosed in item A), including a dielectric material framework, supports a pattern of electroconductive material wires (for example made of tungsten or carbon) equispaced from one another and coupled to a suitable air voltage generator, with an optional interposition of earth coupled conductive material plates.

20. An air cleaning device, according to one or more of the preceding claims, **characterized in that** the construction disclosed in item A) is integrated in a metal frame, which houses therein said constructions of items B) and C) held in an interexchangeable box element operating as a manifold.

21. An air cleaning device, according to one or more of the preceding claims, **characterized in that** at the end of the operating life thereof, said box-like element is removed and replaced by a new one, thereby recovering the full operating capabilities of said device.

22. An air cleaning device, according to one or more of the preceding claims, **characterized in that** said metal frame has a shape, size and arrangement of electric contacts allowing commercially available electrostatic filters of finished available apparatus to be easily replaced without requiring any modifications of the supporting constructions.

23. An air cleaning device, according to one or more of the preceding claims, **characterized by** depositing, in the constructions exposed to said gas or air substances of items B and optionally C, a film of titanium dioxide (TiO_2) of an anatase or rutile type or a mixture thereof in any desired ratio, with an optional addition of substances suitable to extend the wave length range of the electromagnetic radiation necessary for activating said TiO_2 (wsitching of electrons from the valence band to the conduction band) such as Ru compounds and the like, according to the following procedure: a) preparing a 15% solution of polyvinyl alcohol in water; immersing the element to be covered into said solution and then drying at room temperature; b) preparing a 15% suspension of TiO_2 in water; immersing the element to be coated into said suspension; percolating the excess material; quick drying said element to be coated by an exposition to a RF field having a frequency from 2 to 4 GHz for few seconds.

24. An air cleaner including a cold-plasma electrostatic catalytic device, according to one or more of the preceding claims, and substantially as broadly disclosed and illustrated in the preceding description and in the figures of the drawings enclosed in the subject Industrial Invention Patent Application.

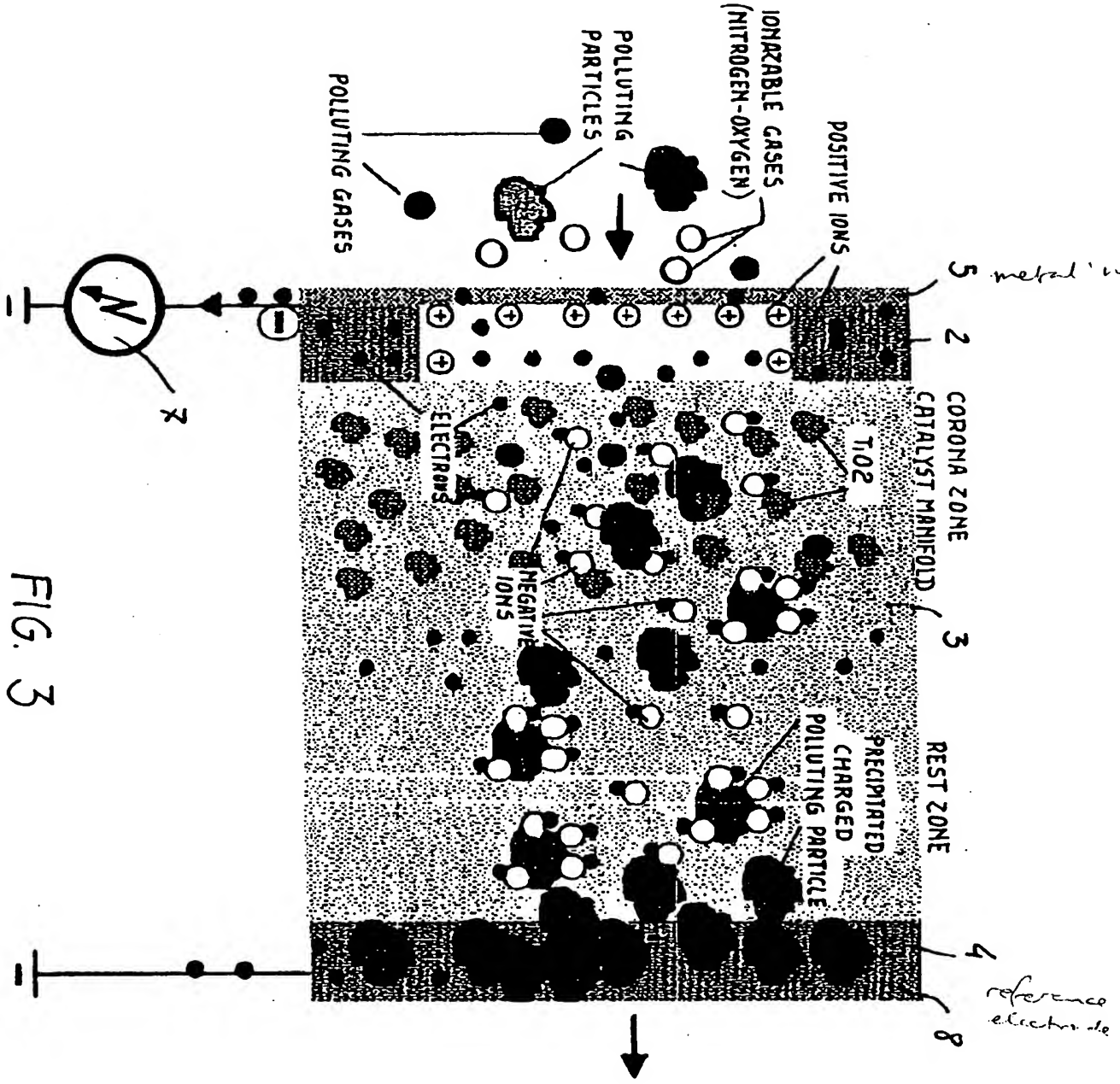

FIG. 3

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PARTIAL EUROPEAN SEARCH REPORT

which under Rule 45 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number EP 01 12 9525

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	WO 99 43419 A (ANDREWS PETER JAMES ;HALL STEPHEN IVOR (GB); SHAWCROSS JAMES TIMOT) 2 September 1999 (1999-09-02) * page 3, line 7 - page 4, line 34 * * page 6, line 1-26 * * page 9, line 1-8 * * page 10, line 7 - page 12, line 2 * ---	1,8-10, 13,14, 16-23	B01D53/32 B03C3/38 B01D35/06 A61L9/22
X	US 5 746 051 A (KIESER JOERG ET AL) 5 May 1998 (1998-05-05) * column 1, line 65 - column 4, line 4 * ---	1,8-10, 13,14, 16-19, 22,23	
X	WO 99 12638 A (HALL STEPHEN IVOR ;MARTIN ANTHONY ROBERT (GB); MORGAN ROSS ALEXAND) 18 March 1999 (1999-03-18) * page 9, line 25 - page 10, line 26 * * page 11, line 26 - page 12, line 29 * * page 14, line 1 - page 18, line 6 * * page 19, line 22 - page 21, line 28 * --- -/--	1,9,10, 13	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

B01D
B03C
A61L
F24F

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

Place of search	Date of completion of the search	Examiner
MUNICH	18 July 2002	Maremonti, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C07)

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PARTIAL EUROPEAN SEARCH REPORT

Application Number
EP 01 12 9525

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	US 5 914 015 A (BARLOW STEPHAN E ET AL) 22 June 1999 (1999-06-22) * column 3, line 16 - column 6, line 4 * ---	1	
X	EP 1 086 740 A (ISHII SHOZO ;NGK INSULATORS LTD (JP)) 28 March 2001 (2001-03-28) * column 4, line 16 - column 6, line 3 * * column 7, line 53 - column 8, line 28 * * column 9, line 25-30; figures 15,21 * ---	1	
X	US 5 843 288 A (YAMAMOTO TOSHIAKI) 1 December 1998 (1998-12-01) * column 1, line 65 - column 5, line 6 * ---	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	US 5 582 632 A (NOHR RONALD S ET AL) 10 December 1996 (1996-12-10) * column 1, line 30 - column 4, line 67 * * column 6, line 39 - column 7, line 28; claims 1,4 * -----	2-7,16	

EPO FORM 1503 03.82 (P04C10)